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ABSTRACT

A pilot study of the pictorial communication in the prose materials was made among students coming from two school settings. The first group was composed of sixth and seventh grade students from average to below average socioeconomic neighborhoods in a large urban industrial community and the second, fifth and sixth grade students from a small, combined agricultural-industrial community. The instructional material was related to science concepts organized around an environmental problem. Pictorial communications were inserted in association with single concepts or to illustrate interrelationships among key concepts. Subjects were asked to read the material. Reactions to each segment, concepts with learning difficulties, usability of pictures in learning, and quality of the material were identified by each subject. Pre- and posttests were used to gather attainment data. Analyses showed the presence of substantial numbers of significant differences between two groups. Child reaction to the organization and assembly of instructional material might influence learning capacity. Prerequisite to development of instructional materials was the gathering of data on the learner's perception of pictorial communications. Detailed procedures for materials development were also suggested. (CC)

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Upgrading Picture Communications Research in Science Education

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INTRODUCTION

Historically, it has been proposed that the ideal means of teaching science is to involve students in laboratory experiments and other activities where they manipulate materials. And as often as possible these students should interact with a variety of natural and social environments to better understand the nature of the scientific enterprise and acquire some of its accumulated knowledge. However, to be practical, there are facts, concepts, and other conceptual knowledges which students might appropriately learn from printed materials.

Where the desired outcomes of instruction are not uniquely associated with development of certain problem-solving skills or utilization of science processes, but rather are oriented to acquisition of conceptual knowledge, learning from prose materials might be more efficient, at least in terms of time, than other means. Further, we know that the existing state of science instruction is heavily dependent on printed materials. Even with increased emphasis on laboratory investigation and the subsequent production of materials, equipment, and kits, much emphasis still is, and will be, placed on the use of texts and other printed materials. For this latter reason, if for none other, it is important to study the capacity of students to learn the substance of science from printed materials.

Even when science instruction is based on laboratory experimentation and other materials-oriented activity, the printed medium is a valuable part of the comprehensive instructional program. Ideas or suggestions for action are often introduced through printed materials; leading to verification and giving rise to questions requiring investigation or experimentation, or other types of exploration. Whether prose introduces problems to be solved or adds clarity

to problems under investigation, it is and will continue to be a valuable component of instructional systems.

We also know that complete instructional systems require alternative instructional modes to better meet the needs of individuals - the kinds of materials they prefer to interact with, the kinds of materials they learn best from, the kinds of materials appropriate to pacing situations. The printed medium will continue to be a major ingredient of the instructional program, and thus, we should be about determining how children of various characteristics can profit from these materials, singly or in conjunction with other parts of a more complex program.

THE PROBLEM

Interest in pictorial communication in science education research developed as an integral part of research and development efforts on improving science instruction. The research is conducted to refine research and development strategies for developing instructional materials. Learning from prose is studied as part of a larger R & D program, to ascertain how children learn more effectively from prose materials either when used to initiate instruction or when used to achieve closure for instruction begun with activities and experimentation.

Many developers of instructional materials have used elaborate procedures to validate materials based on internal criteria; i.e. determining whether materials developed to meet certain goals meet those goals. But there is inadequate input from the intended consumer of these materials in preliminary development activity, input reflecting the nature of the consumer and his interaction with the nature of the substance to be learned. Therefore the results

often consist of adult impositions due to the absence of input regarding the learner's perception of the nature of the instructional materials. The research to be reported and the related discussion have evolved out of the concern for refining this aspect of the techniques for developing instructional materials.

This concern for refining technique stems from the larger problem on the nature of children's learning. There has been persistent pursuit of "how children learn", but as indicated, the related investigations are derived from adult conceptions of learning. More emphasis should be placed on determining how a child learns by asking the child how he learns. For unless the instructional material or the instructional method, whatever it be, has meaning to the learner, that which he "learns" has minimal potential for survival. The learner's perception of the role and design of instructional materials sheds clarity on what he is expected to accomplish. Input is needed from the consumer of the materials sooner and in a more open fashion. Rather than only getting the consumer's reaction to actual chunks of material, his input is needed in preparing those chunks.

Related Questions

The results of existing research on pictorial communication in prose learning brings to mind the laboratory versus demonstration research from earlier in this century. Much conflict is found as to whether the laboratory or the demonstration was a more efficient mode of instruction. A comparison of those studies with studies on pictorial communications research reveals many of the same sources of inadequacy in design which could only produce conflicting results.

One reason the studies reveal conflict is that the efficiency of instruction is not examined in light of agreed upon goals of science teaching. If researchers are not concentrating their efforts on the attainment of the goals of science education, there is no standard criterion for measurement. One would expect some "conflict" in results from the basic laws of probability but without agreement on expectations, confusion can only result. In addition, there is little consistency in what is measured. Each researcher develops his own measurement device. So neither the objectives nor the measurement device is a variable held constant.

Further, there is no reference to the nature of the concepts to be learned. There is no research pattern for study of classificatory concepts, relational concepts or theoretical concepts. Thus the nature-of-the-concept variable is not controlled. Failure to examine the nature of the concept(s) in designing studies will produce conflicting results.

In addition, there is little or no information presented as to what the learner already knows, or what his other entry characteristics are. For example, what is his stage of cognitive development? Reading, of course, is one measure, but this may be a lesser quantity than others, such as perceptual awareness or the ability to form models. Premeasures of learner characteristics and an understanding of the total instructional set are critical.

There is also no indication of the learner's notion of the function of the pictures in instructional materials. We know that pictures are forms of representation of various phenomena and conceptual ideas. These may consist of objects such as animals, abstract concepts, such as the chemical bond or interactions between and among concepts such as the producer, consumer, decomposer interrelationship. Pictures are a kind of representation of physical,

mental, or mathematical models formulated from information acquired by viewing physical objects or things or through some sort of secondary data-gathering medium. But does the learner understand this function of the picture as a communications medium? If one assumes that the learner perceives the function of the prose materials to be instructional, then we can assume that he will make a reasonable attempt to learn from those materials. However, the contribution of the pictorial communication in the prose materials will then be a function of the learner's perception of their contribution toothe total printed package and will be substantially influenced by his perception of the nature of pictures. If the learner does not recognize pictures as abstractions, then their contribution to the learning process may be totally beyond his comprehension.

There is also no evidence of association with other materials. Often there is no indication whether other materials have been used to prepare students for encounter with the prose material or whether other materials are to be used to alleviate deficiencies following use of the prose materials. Any instructional material is part of a complex instructional "program" involving in-school and out-of-school experiences.

A further question often neglected in the pictorial communication research is whether the pictures parallel the information load. For example, if the information load is light throughout the materials, then few pictures may be needed. But if the information load is heavy, it may be necessary to introduce large numbers of pictures of various kinds in sequential fashion rather than dispersing them throughout. These questions cannot be readily answered

unless one goes to the consumer of these materials to see in fact where he feels that pictures would add clarity and what the nature and number of these pictures might be.

And last, but certainly not least, there is little, if any, indication of conferring with the consumer in the development of the materials. We may be including pictures when the consumer feels they are not needed and thus they become nothing but noise. Or pictures may be so complex that they become a distraction rather than an aid.

The above discussion indicates in brief the enormous complexity of research on the role of pictorial communication in science education. Obviously, the interactions between the substance, the learner, and the instructional means is so complex that one could appropriately question whether our studies really shed any new light on the ability of pictures to contribute to learning from prose. If this is the case, a major deficiency can be attributed to a too simplistic view of the nature of prose instruction and the role of pictorial communication in prose. We have not gone to the consumer of materials to obtain information for use in preliminary development work. And so much of our research is of group variety that we camouflage the subtle differences due to individuals and small groups within and across various communities. Thus, we can expect many NSD studies and conflict in the SD studies. We have forgotten that the major question is how children learn. They know this better than any adult attempting to make an imposition on them and their interaction with learning environment.

PROCEDURE

The instructional material used in this pilot study consisted of a "book" designed to teach science concepts within the context of a story about an

environmental problem. The prose was written to teach these concepts as conceptual knowledge needed to arrive at a decision for alleviating the problem. A limited number of key concepts were selected for inclusion. Results of research on concept learning were employed to organize the sequence and frequency of presentation of attributes, examples, and non-examples of the concept, associations between subordinate, coordinate and supraordinate concepts, and the relationships between concepts to form principles and higher levels of cognitive learning.

Pictorial communications (artists' drawings) were inserted in association with single concepts or to illustrate interrelationships between and among two or more key concepts. These were positioned to maximize the proximity of the pictorial communication with a point at which the information load was heavy.

The students involved came from two community settings. One group was from average to below average socioeconomic neighborhoods in a large urban industrial community. The second group came from a small community with a combined agricultural industry character. Students in the urban community were in grades six and seven, while the students in the smaller community were in grades five and six. The majority of the students in the urban community were blacks.

The instructional materials were presented to the students in a regular classroom environment. The books were read in sections over a period of several days. Students were given instructions as to what portion of the book to read on a given day and were allowed enough time to complete reading the required segment for the day.

Data were obtained by administering pre- and post-tests of concept attainment and asking the students to record their reactions to specific

questions about the content and organization of the book. These latter questions fell into four major categories. Questions in Category One required that the students give their reaction to each of the five major segments (chapters) of the book. Questions in Category Two asked the students to identify which concepts they felt were difficult to learn. Questions in Category Three asked the students to indicate how the pictures had helped them learn from the book. The three specific questions were whether the pictures had assisted them: (a) enjoy the book more (b) better understand the book (c) didn't help. Questions in Category Four were in reference to the length of the book, its overall difficulty, and whether or not the students felt its quality was such that they would suggest that others use it.

RESULTS

A summary of the students' reaction to the content and organization of the prose materials is presented in Tables 1 and 2. Results of the multivariate analysis of variance reveal a significant difference for grade levels within the urban community and marginal differences (between .05 and .10) for city, grade within the smaller community, city x sex, and grade x sex within the urban community. After removing the covariates of reading ability and reading ability squared, the probability levels for the significant differences change but all but one of the former differences still exist. Again, there is a significant difference between grades in the urban community, but one of the marginal significant differences is lost, that being grade level within the smaller community.

An examination of the significant differences for univariate analyses corresponding to the multivariate analyses of variance and covariance indicates that the more prominent contributing factors are selected book chapters and

student reaction to whether or not the pictures helped them better understand the book. Pictures helping to better understand the book shows up as a significant univariate result in the majority of those instances where there was a significant multivariate result.

Table 3 shows significant differences on the multivariate analyses of variance for city and grade level within the smaller community. The grade level difference within the urban community is marginal.

The results of the multivariate analysis of covariance for concept attainment on Sum (pre & post) are reported in Tables 4 and 5. These differences were computed after removing the covariates: reading ability, reading ability squared, and reactions to chapters of the book. On Sum, significant differences are noted for city and grade level within both communities. However, on the concept attainment differences, the grade level factor within the urban community becomes marginal.

Tables 6 and 7 show the multivariate analyses of covariance for concept attainment scores, both Sum (Table 6) and Difference (Table 7) with covariates of reading ability, reading ability squared, reaction to pictures, and recommending the book to others. On Sum significant differences are noted for city and grade level within both communities. However, on the concept attainment score differences with these same covariates eliminated, there is a significant multivariate difference for city only.

Table Eight shows the step-wise regression analysis for both the concept attainment Sums and the concept attainment Differences. From this table, it can be noted that the combination of reading ability and reading ability squared either contribute the highest per cent of variance or are very close to contributing the most of variance. The analysis shows significant differ-

ences for reading and reading ability squared combined, but not for either reactions to sections of the book or the combined reaction to pictures and book quality. Even though significant differences do not exist for other than the combination of reading ability and reading ability squared, it should be noted that reactions to pictures or book sections do contribute from five to seven per cent of the score variance.

DISCUSSION

As indicated earlier, the study reported was an element of a more comprehensive research and development effort. The work should be considered pilot activity which accounts for some inadequacy in design. Therefore, the results of the study can give us hints or suggestions for proceeding but should not be construed as conclusive results leading to sweeping generalizations about the role of pictorial communications in prose learning in science.

We find that there are substantial numbers of significant differences between the groups. At this stage we can only speculate as to the causes of these differences, but it is clear that there is more influence on the differences than the respondent's ability to read. We can infer that there is support for the earlier contention of the need for an improved system and better models for carrying on research regarding pictorial communication in learning science. The differences in perceptions of the materials by the involved groups demonstrates that we should start with the consumer in development, making attempts to meet his needs and concerns and work with his preferences in mind in materials preparation. Improved input from the consumer is needed and we also need better control of the possible variables that may be contributing to these significant differences.

The results indicate that children's reaction to the organization and assembly of instructional materials may, in fact, influence their capacity to learn from these materials. This could be a motivational factor, but it could also be due to effects such as the children's perception of the function of pictorial communications in the prose. Support for this contention is derived from the results which indicate that book chapters and pictures appear

to contribute to children's overall reaction to the material. Informal discussions between the investigators and the children during the pilot activities also lend credibility to inferences from the sketchy data.

Questions which must be dealt with to improve procedures for conducting research on pictorial communication in science education include the following:

1. What is the learner's perception of pictorial communication and its function in the context of instruction?

2. Are types of pictorial communications designed to serve learners with certain characteristics and cognitive abilities?

3. What is the relationship of placement and type of pictorial communication and the learning of classes of concepts?

4. What results are obtained when materials are held constant? Rather than comparing the "methods", what kind of differential results are gotten when using the same methods with groups of children of different characteristics?

This is only a sample of the universe of the questions to deal with, but they reflect the need for improved procedures evolving from models which simultaneously give more emphasis to the nature of the concept and the nature of the learner. Possibly, we should lessen the emphasis on the comparative, A versus B, because in instruction it is more likely that a combination of A and B will be more efficient.

At this time, I would like to propose some tentative ideas about improving materials development activities. These ideas are based on at minimum two apriori assumptions. (1) The development of instructional materials should be focused on preparing materials for groups of children with a common set of characteristics rather than being assembled to have "some" usability with the total population of children within and across communities. (2) The preliminary or formative activity in materials development is probably more important than summative study.

Prerequisite to development activity is the gathering of more complete and better data on the learner's perception of pictorial communications in instruction, in total and as an element of prose materials. For example, do the learners see pictures only as representations of reality? Would young children perceive a picture of a horse to be an exact representation of the horse's color, size, and other characteristics? Do learners perceive of some pictures as being abstract forms of abstract things? Answers to these and related questions are needed before conducting any research on pictorial communication in science education.

A second prerequisite to development activity is to determine the nature of the target group to be served. To develop materials derived only from the structure of the discipline may not be fruitful. There is already sufficient research to indicate that the psychological development of the child does not proceed parallel to the historical development of concepts. Therefore, the group to be served needs to be thoroughly described before development begins. The target group should be characterized as to age, cognitive development, types of experiences, perceptual awareness, whether modeler or non-modeler, reading ability and the like. Further, these data should come from formal or informal test results, not only educated guesses.

Once the nature of the target group is known and data are available about their perception of the nature and role of pictorial communications, one should move to the nature of the "class" of conceptual knowledge to be learned. The class of concept is going to be a major factor in determining the type of pictorial communications that might be used. For example, if the concept is animal, it may be appropriate to use photos. However, if the concept is atom, then certain line drawings or artists' sketches may be more appropriate than pictures. Children are apt to interpret photos as representations of the real

thing. Pictorial descriptions of atoms are best representations of our mental model of the unseen. These factors, on the surface very subtle, are major considerations in conducting research. Pictures dealing with classificatory concepts should be associated with attributes or examples and non-examples of the concept. When one deals with relational or theoretical concepts other constraints will influence the selection of pictorial communications.

The next step in development would be the construction of an initial draft of the prose base. (The class(es) of concept and information about the target group will determine the nature of the prose and the basic organization.) Parallel to the development of the prose, would be the preparation of a set of possible pictorial communications for insertion. This set of pictorial communications should represent a wide range of formats and variations within formats - pictures, line drawings, artists' drawings, sketches, graphs, etc.

The prose draft and the set of possible pictures should then be examined by samples of the potential consumers. One sample should read the prose materials in the presence of an investigator. As the children go through the material, they should make suggestions where pictorial communications might assist in clarifying the prose substance. These suggestions would deal with "where might a picture help", "what kind of picture might help", or "how many pictures might be needed". Another sample of students should read the prose material in the presence of an investigator. However, in this instance the investigator should make available the set of possible pictorial communications. Students should make suggestions about which pictures they would select to help clarify the prose, "what pictures might help", "which ones are better than others", "how many are needed", and "what combinations are more useful".

Results of these preliminaries would be used to prepare the pilot drafts of the materials. The pilot draft(s) should be examined by both the former and new samples from the population of students to be served, including more interviews of the picture-production variety as well as the picture-selection variety. By the time these steps are completed, the investigator should have a reasonably good conception for the organization of materials which are responsible to and responsive to the nature of the subject, the general characteristics of the target group, and the specific impressions from samples of this consumer group.

With refined materials studies can be conducted where variables can be better controlled than in the past. The materials, the class of concept, and general categories of child characteristics can be held constant. Single variables can be manipulated to determine whether in fact reading ability or varying cognitive ability produce differential effects in the use of materials.

This suggested procedure for materials development might appear contradictory to commonly used procedures in research. But it is purposely posed to question the validity of using the natural science model for carrying on scientific investigation. An experiment cannot be conducted until variables can be controlled. The procedure suggested here would increase the probability of identifying relevant variables so materials can be developed in a way that we have some control over the variables when doing our "experimental" studies.

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TABLE I

MULTIVARIATE ANALYSIS OF VARIANCE
STUDENT PERCEPTION OF PROSE

	$p <$ (M.V.F.)	$p <$ (U.N.F.)		
City	.0708	.0440	1	SWTR
		.0339		DFOP
		.0057		END
		.0248	2	DECM
		.0226		MICR
		.0469	3	UNBT
		.0360	4	TLNG
Grade/Milwaukee	.0162	.0617	1	END
		.0387	2	EDIT
		.0610		MICR
		.0079	3	ENJN
		.0295		UNBT
Grade/Menasha	.0992	.0006	1	END
		.0037	2	MICR
		.0769	4	TLFR
Sex	.2764	.0088	3	UNBT
City x Sex	.0718	.0002	1	PRBS
Grade x Sex/ Milwaukee	.0834	.0029	1	PRBS
		.0757		DFOP
		.0560	3	UNBT
Grade x Sex/ Menasha	.8766			

1. Chapters
2. Concepts
3. Pictures
4. Impression

TABLE II

MULTIVARIATE ANALYSIS OF VARIANCE

(COVARIATES: READING & READING^2)

STUDENT PERCEPTIONS OF PROSE

	$p <$ (M.V.F.)	$p <$ (U.N.F.)		
City	.0673	.0454	1	SWTR
		.0315		DFOP
		.0037		END
		.0191	2	DCMP
		.0242		MICR
		.0426	3	UNBT
		.0373	4	TLNG
Grade/Milwaukee	.0357	.0539	2	EDIT
		.0687		MICR
		.0197	3	ENJN
		.0247		UNBT
Grade/Menasha	.1702	.0181	1	END
		.0862	2	DCMP
		.0099		MICR
Sex	.2238	.0089	3	UNBT
		.0053	4	RDVL
City x Sex	.0875	.0002	1	PRBS
Grade x Sex/ Milwaukee	.0957	.0022	1	PRBS
		.0852		DFOP
		.0609	2	SWTR
		.0599	3	UNBT
Grade x Sex/ Menasha	.9305			

TABLE III

MULTIVARIATE ANALYSIS OF VARIANCE
CONCEPT ATTAINMENT-DIFFERENCE

	$p <$ (M.V.F.)
City	.0298
Grade/Milwaukee	.1006
Grade/Menasha	.0051
Sex	.8471
City x Sex	.1341
Grade x Sex/Milwaukee	.7893
Grade x Sex/Menasha	.5477

TABLE IV

MULTIVARIATE ANALYSIS OF COVARIANCE
CONCEPT ATTAINMENT-SUM
(READING, READING^2, BOOK SECTIONS)

	$p <$ (M.V.F.)
City	.0002
Grade/Milwaukee	.0007
Grade/Menasha	.0001
Sex	.4853
City x Sex	.9458
Grade x Sex/Milwaukee	.6884
Grade x Sex/Menasha	.2999

TABLE V

MULTIVARIATE ANALYSIS OF COVARIANCE
CONCEPT ATTAINMENT-DIFFERENCE
(READING, READING^2, BOOK SECTIONS)

	$p <$ (M.V.F.)
City	.0221
Grade/Milwaukee	.1032
Grade/Menasha	.0269
Sex	.9064
City x Sex	.0889
Grade x Sex/Milwaukee	.6951
Grade x Sex/Menasha	.5173

TABLE VI

MULTIVARIATE ANALYSIS OF COVARIANCE
CONCEPT ATTAINMENT-SUM
(READING, READING^2, PICTURES, IMPRESSIONS)

	$p <$ (M.V.F.)
City	.0012
Grade/Milwaukee	.0016
Grade/Menasha	.0001
Sex	.2505
City x Sex	.8445
Grade x Sex/Milwaukee	.4530
Grade x Sex/Menasha	.5173

TABLE VII

MULTIVARIATE ANALYSIS OF COVARIANCE

CONCEPT ATTAINMENT-DIFFERENCE

(READING, READING^2, PICTURES, IMPRESSIONS)

	$p <$ (M.V.F.)
City	.0193
Grade/Milwaukee	.1786
Grade/Menasha	.1970
Sex	.7267
City x Sex	.1782
Grade x Sex/Milwaukee	.8615
Grade x Sex/Menasha	.5484

TABLE VIII

STEP-WISE REGRESSION ANALYSIS

CONCEPT ATTAINMENT-SUM

	$p <$	% Variance
Reading & Reading^2	.0496	6.3908
Pictures & Impression	.4590	6.9969
Book Sections	.8500	2.1094

CONCEPT ATTAINMENT-DIFFERENCE

Reading & Reading^2	.0001	36.6480
Pictures & Impression	.4581	4.7411
Book Sections	.0956	6.4278